



U.S. Department of Energy
Energy Efficiency and Renewable Energy



US Geothermal Technology Program

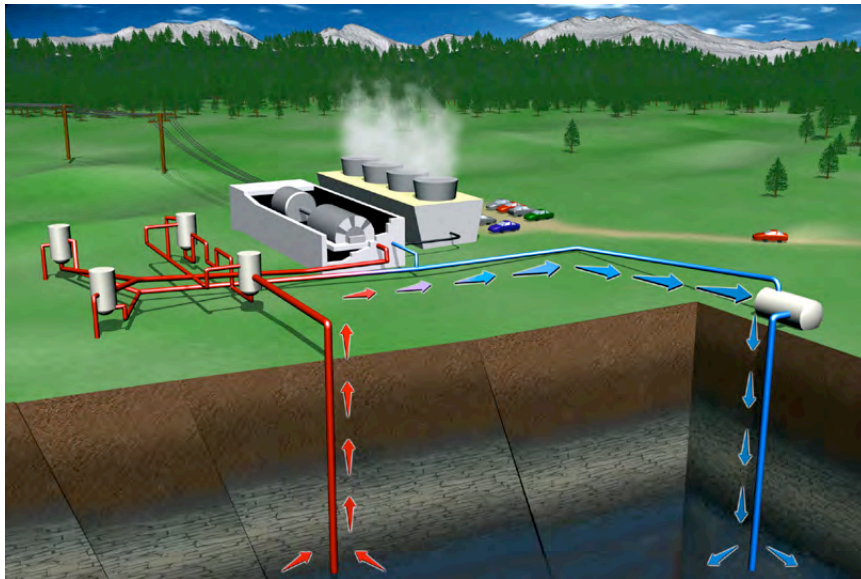
World
Geothermal
Conference 2005

Roy Mink
Program Manager



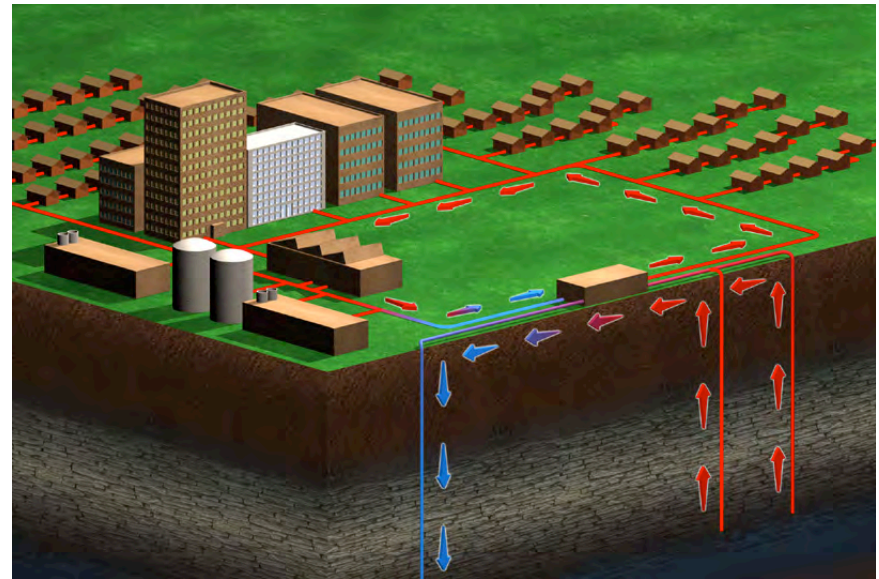
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Geothermal Energy Technologies



Electricity Generation

- Distributed Power
- Central Station Power



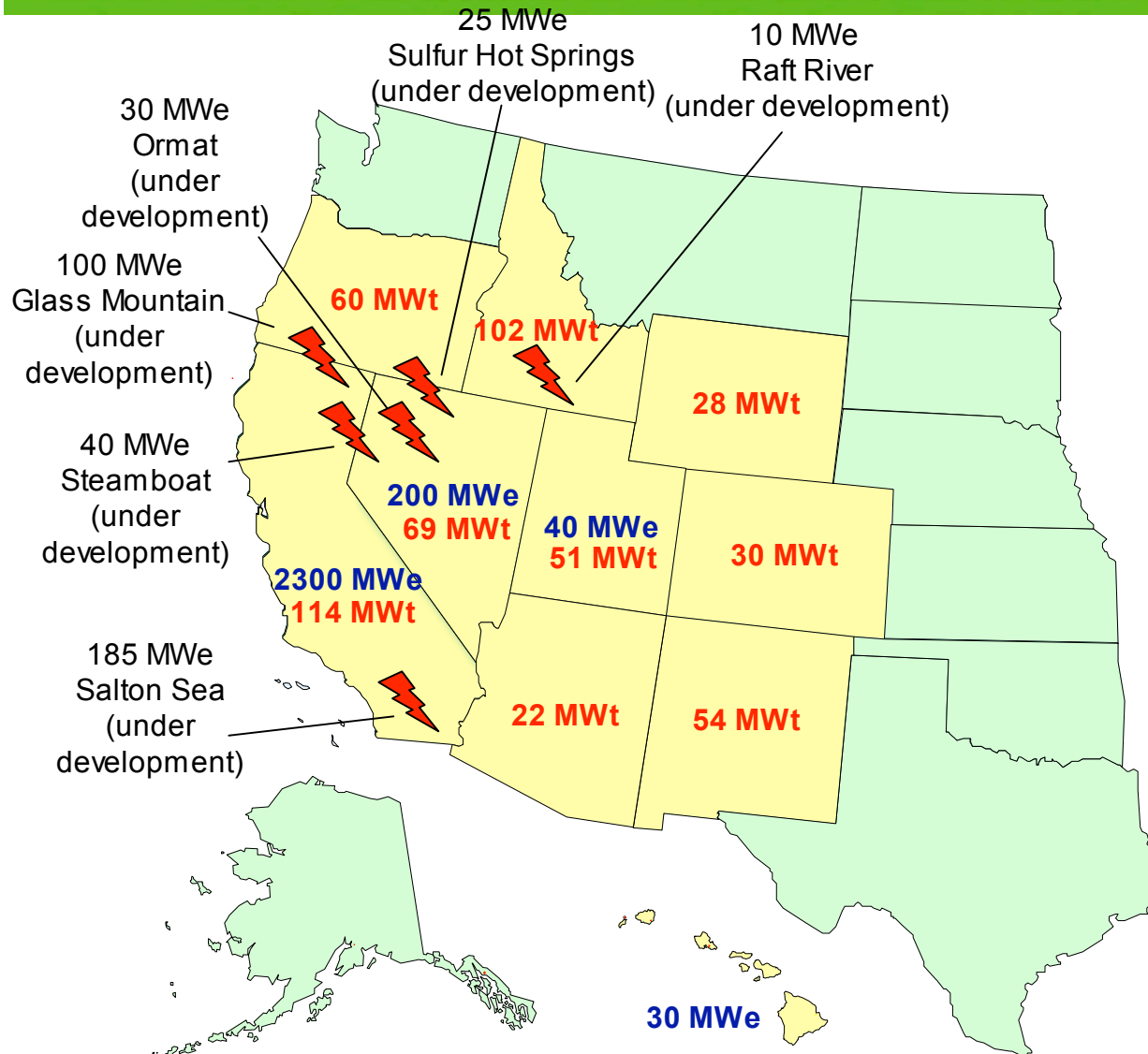
Heat Production

- District Heating
- Process Heat
- Agriculture
- Aquaculture



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Present and Near-Term Capacity



Installed:

About 2600 MWe (electric)

Over 600 MWt (heat)

400 MWe under development (electric)

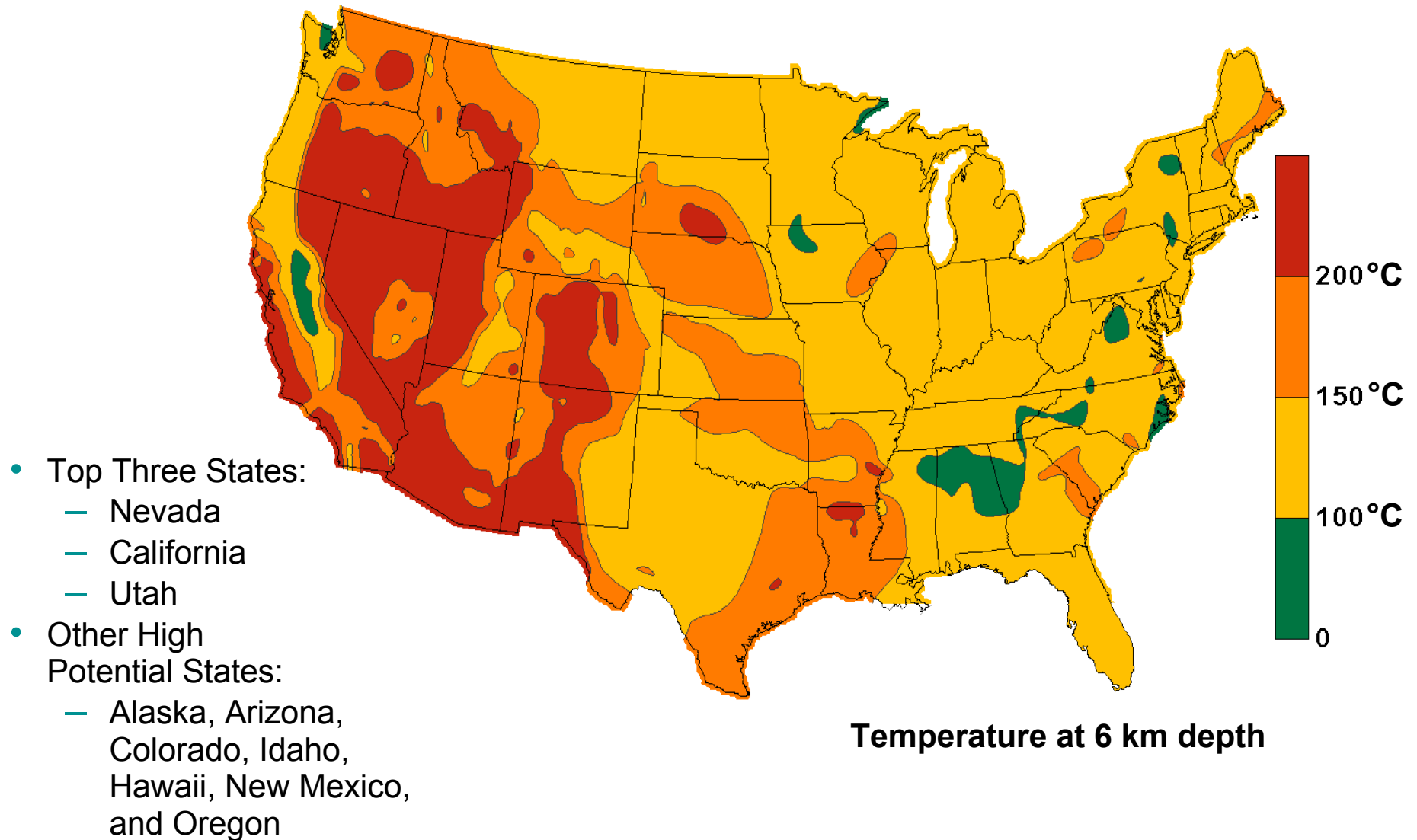
More Than 20 MW

Less than 20 MW



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Geothermal Resource Potential





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Geothermal Energy Increasingly Competitive

1980: 10-16 cents/kWh

2000:
5-8 cents/kWh

- Improved technology
- Reduced drilling costs
- Expanding resource base

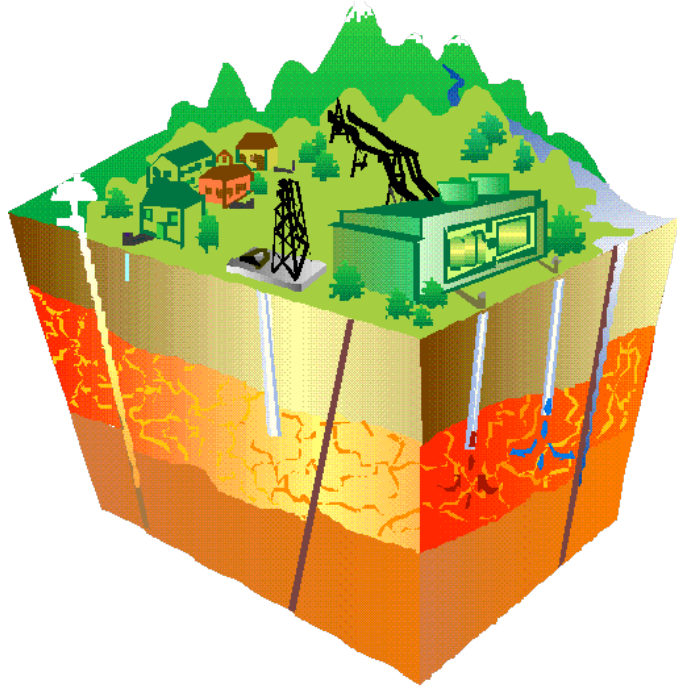


2010 Goal: Less than 5
cents/kWh



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Program Vision and Mission



The Geothermal Technologies Program has a vision of geothermal energy as the nation's environmentally preferred baseload energy alternative.

The Program's mission is to work in partnership with U.S. industry to establish geothermal energy as an economically competitive contributor to the U.S. energy supply.



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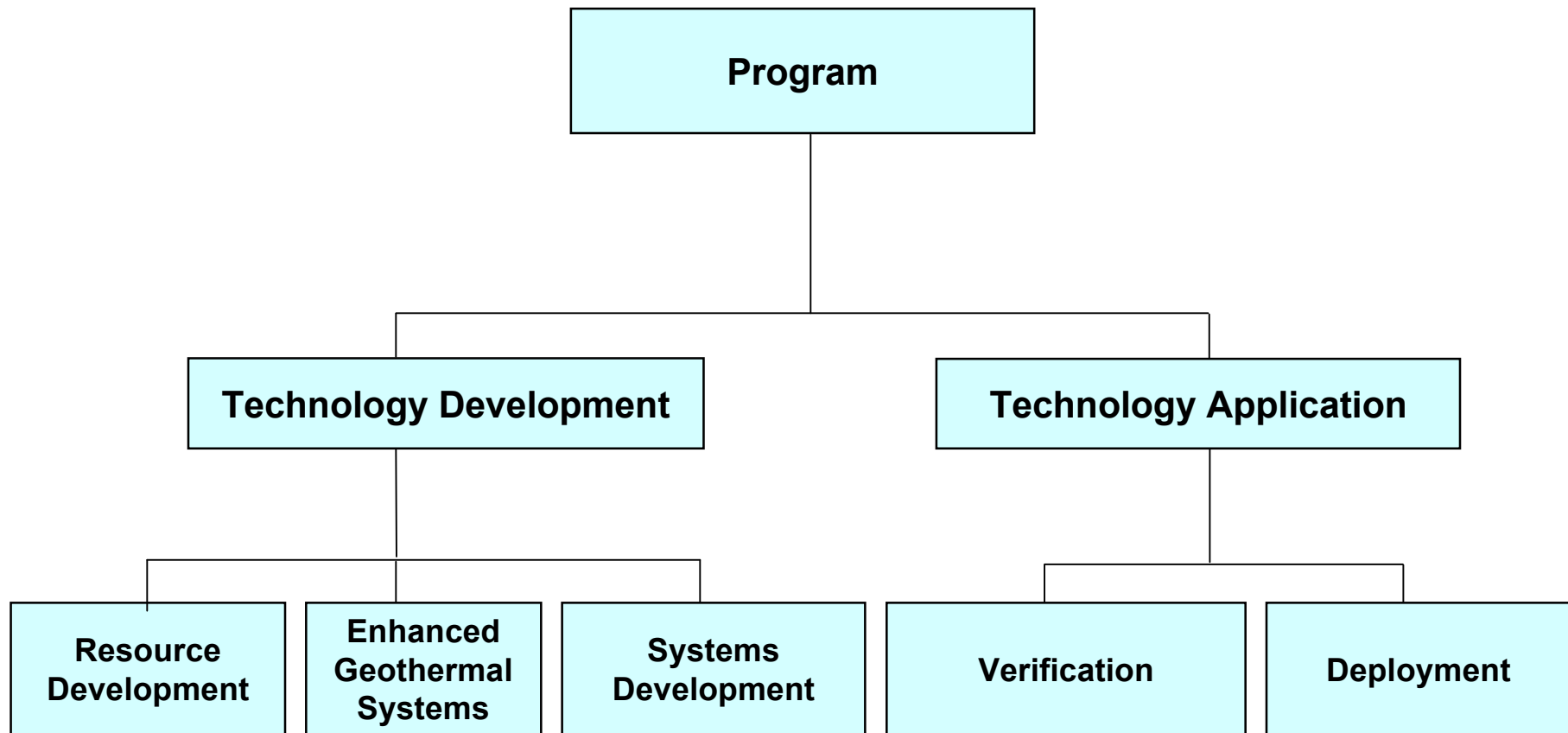
Strategic Program Goals

- Reduce the levelized cost of hydrothermal development to less than 5 cents/kWh by 2010
- Increase the economically viable geothermal resource to 40,000 megawatts by 2040
- Decrease the levelized cost of electricity from Enhanced Geothermal Systems to less than 5 cents per kWh by 2040



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Geothermal Technology Program Budget Structure





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Resource Development

Double the exploration success rate from 20 percent in 2000 to 40 percent by 2010

- Develop a suite of preferred remote sensing and exploration techniques that can be used by industry for locating hidden geothermal resources
- Update assessments and characterizations of known resources.

Accomplishments to Date:

- Demonstrated that aeromagnetic surveys can help find hidden faults

Present Status:

- Reviewing applicability of modern remote sensing tools

Path Forward:

- Research to improve exploration tools
- Resource assessment in collaboration with state agencies and USGS to locate exploration targets





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Enhanced Geothermal Systems (EGS)

Create hydrothermal reservoirs at sites lacking economic hydrothermal resources

- Conduct research on improved and innovative technologies for creating and managing EGS.
- Apply technological tools in partnership with industry at selected field locations.

Accomplishments to Date:

- Technical feasibility of EGS demonstrated at various sites

Present Status:

- Three cost-shared projects underway
- Twelve R&D projects awarded to universities and companies

Path Forward:

- Form Expert Panel
- Conduct Strategic Planning
- NAS/NRC Study



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Systems Development – Advanced Drilling

Reduce Cost of Drilling 25% by 2008 Compared to 2000 Costs

- Improve the component parts of a drilling system to perform essential functions quickly, reliably, and cheaply.
- Investigate revolutionary advances in drilling materials and techniques with the target of drilling twice as deep for the same cost.

Accomplishments to Date:

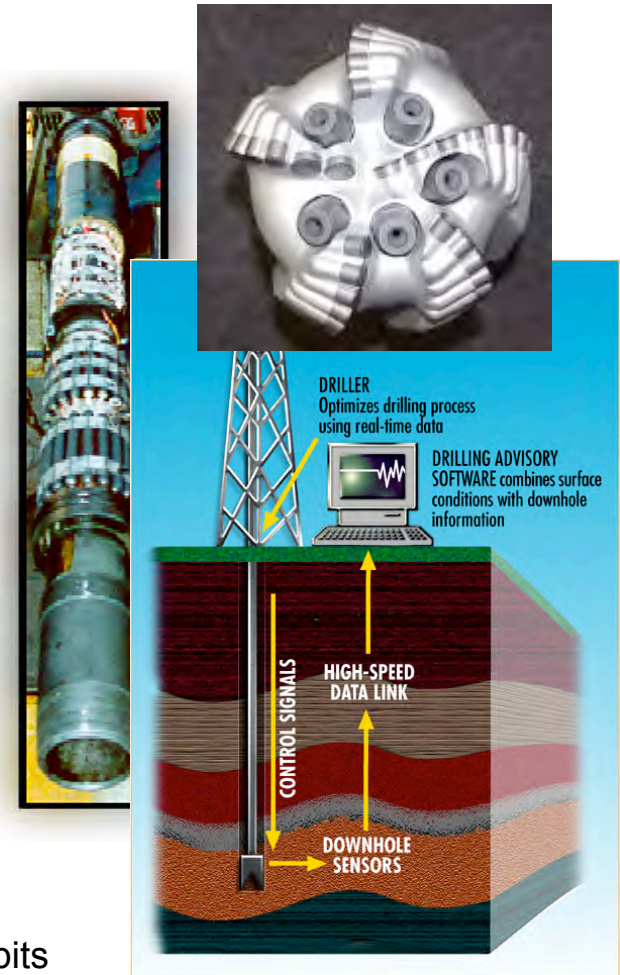
- Diagnostics While Drilling (DWD) proof of concept
- Hard rock drill bits
- Polyurethane grout for lost circulation control
- High-temperature integrated circuits for logging tool

Present Status:

- DWD system test with proprietary drill bits
- Drill bit database being developed
- Improvement of polyurethane deployment system

Path Forward:

- High-speed data link and smart sub-assembly for DWD
- Further improvements to polycrystalline diamond compact (PDC) drill bits
- Advanced drilling technologies





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Systems Development – Heat and Power Systems

Reduce the capital cost of geothermal surface systems by 20 percent by 2010

- Develop heat rejection systems with major efficiency improvements, especially for lower-temperature resources.
- Develop advanced cycles using mixed working fluids that offer the potential for major efficiency improvements, especially for relatively low-temperature resources.
- Reduce operations and maintenance costs through optimized maintenance schedules, better construction materials, and hardier instruments.

Accomplishments to Date:

- Technology for Salton Sea metastable expansion
- Innovative condensers
- High performance coating materials

Present Status:

- Evaluating condensers to significantly increase air-side coefficient
- Supporting technologies (monitors, non-condensing gases removal)

Path Forward:

- Innovative cycles
- Operating strategies





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Verification

Locate 20 new geothermal fields by 2010

Develop collaborative efforts with industry to support exploration for and definition of new geothermal resources

- Geothermal Resource Exploration and Definition I (GRED I) is in closeout
 - Seven Projects Funded (4 States), approximately 80 MW of resource located
- GRED II is ongoing
 - Seven Projects Funded (5 States), Six Ongoing
 - U.S. Geothermal Inc., Raft River, Idaho
 - Noramex Corporation, Blue Mountain, Nevada
 - Lake City Geothermal Inc., Lake City, California
 - AmeriCulture Inc., Animas Valley, New Mexico
 - Layman Energy Associates, Truckhaven, California
 - Northern Arizona University, San Francisco Volcanic Field, Arizona
- GRED III closed 6/04
 - Eleven Projects Selected (6 States); Negotiations Ongoing
 - Three Phases
 - Three Risk Areas
 - Cost Shared Approach
 - Cooperative Agreements – DOE Involvement



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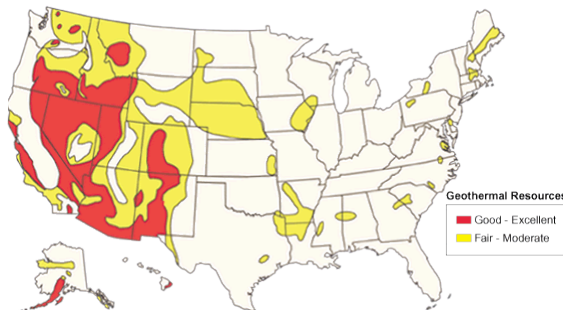
Deployment – GeoPowering the West

Double the number of states with geothermal electric power production facilities from 4 to 8 by 2006

- (1) Continue support of the National Geothermal Collaborative, which brings together involved stakeholders from all sectors to deal with institutional issues.
- (2) Gather and disseminate information about geothermal resources, including the completion of the geothermal leasing workbook.
- (3) Add two new State working groups, bringing the total number of groups to nine.



**GEOPOWERING
THE WEST**



- DOE Leadership
 - State Geothermal Workshops/Working Groups
 - National Geothermal Collaborative
- State and Local Outreach
 - State Energy Program
 - Resource Mapping/Publications
 - Native American Involvement
 - Technical Assistance
- Industry Partnerships
 - Broad-Based Awards for Outreach Activities
 - Support for Direct-Use Community



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Geothermal Budget

Funding Profile (\$ thousands)

	FY2004	FY2005	FY2006 Req.
Technology Development	16,425	15,727	19,799
- Resource Development	2,019	2,536	3,655
- Enhanced Geothermal Systems	6,680	6,812	7,898
- Systems Development	7,726	6,378	8,246
Technology Application	6,238	6,311	3,500
- Technology Verification	3,500	3,174	2,000
- Deployment	2,738	3,137	1,500
Congressionally Directed	1,962	3,558	
Total	24,625	25,597	23,299



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Program Accomplishments

R&D 100 Awards

Acoustic Telemetry (FY2003)

- High Speed Data Link

Low Emission Atmospheric Monitoring Separator (FY2003)

CurraLon Coating System (FY2002)

- Low-cost alternative to high-alloy steels and titanium

Silica Recovery from Brine (FY2001)

- Produces high-quality silica as an added source of revenue

ThermaLoc CaP Cement (FY2000)

- Used in harsh, hostile environments
- Commercialized by Halliburton
- Significantly improves well economics

Advanced Direct Contact Condenser (FY1999)

- Increased output of Geysers Unit 11 by 5%





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Factors Influencing Future Development

- Land Access and Permitting – Federal, State, and local
- Production Tax Credit for Geothermal
- Renewable Portfolio Standards
- Transmission
- National Resource Assessment
- Geothermal Technology Improvements



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Resource Development

	FY05 Budget
Geochemical Techniques	
Gas and Isotope Geochemistry (LBNL)	\$200k
Geophysical Techniques	
Seismic Imaging (LBNL)	\$75k
Integrated 3D Geophysical Modeling (LBNL)	\$240k
Localized Strain as an Exploration Tool (LLNL)	\$250k
Remote Sensing for Geothermal Exploration (LLNL)	\$200k
Remote Sensing of Localized Strain (LBNL)	\$75k
Resource Assessment	
Exploration Statistics (INEEL)	\$225k
National Resource Assessment (USGS)	\$400k
Research Integration and Oversight	
Laboratory Technical Support (INEEL; LBNL; LLNL)	\$175k



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Enhanced Geothermal Systems

	FY05 Budget
EGS: Research Integration and Oversight	\$1,207k
Programmatic Support and Oversight	350k
Research Management, Integration and Analysis	500k
Long-Term Potential of Enhanced Geothermal Systems	357k
Field Experiments	\$3,533k
Creation of an EGS through Hydraulic and Thermal Stimulation	1443k
Geysers Permeability Enhancement	
Desert Peak East EGS Reservoir	500k
New Site Experiment	1590k



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EGS R&D at National Laboratories

EGS Research and Development (National Laboratories)	\$2,408k
INEEL	
Reservoir Characterization and Numerical Tools for EGS Resource Management	260K
Parametric Analyses of EGS Reservoir Properties	100K
Analysis of Non-traditional Stimulation Methods and Rock Mechanics for EGS	165K
LBNL	
Geothermal Reservoir Dynamics	150K
Application of Microearthquake Monitoring for Evaluating and Managing the Effects of Fluid Injection at EGS Sites	150K
Geochemical Study of the Effects of Fluid Injection at EGS Sites	75K
Evaluation of fluid/heat transfer efficiency through modeling of mineral-water-gas reactions and monitoring of CO ₂ , 14C, and 18O/16O in extracted fluids and gases	50K
Case Studies	49K
LLNL	
Prediction and control of the attributes of induced fractures in Enhanced Geothermal Systems	100K



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EGS Winning Proposals

- Duke University: ICEKAP 2004: Collaborative Joint Geophysical Imaging Project at Krafla and IDDP (\$170k)
- Pennsylvania State University: Stress- and Chemistry-mediated Permeability Enhancement/Degradation in Stimulated Critically-stressed Fractures (\$163k)
- Pinnacle Technologies, Inc.: Evaluation of Oil-Industry Stimulation Practices for EGS (\$164k)
- SAIC: Evaluating Permeability Enhancement Using Electrical Techniques (\$153k)
- University of California San Diego: Models of Subsurface Chemical Processes Affecting Fluid Flow (\$159k)
- University of North Carolina at Chapel Hill: Real-time Fracture Monitoring in EGS with Seismic Waves (\$308k)
- University of Utah – EGI
 - Elucidating Critical Controls on Fracture and Stratigraphic Permeability in Hydrothermal and EGS Domains of the Greater Salton Sea Geothermal Field and Vicinity (\$169k)
 - The Role of Low-Angle Extensional Tectonics, Flat Fracture Domains, and Gravity Slides in Hydrothermal and EGS Resources of the Western United States (\$165k)
 - Geochemical enhancement of EGS reservoirs: an integrated field and geochemical approach (\$166k)
 - Predicting Fracture Characteristics in Volcanic Environments as a Guide to Locating EGS Reservoirs (\$158k)
 - Chemical Stimulation of Engineered Geothermal Systems (\$166k)
 - Imaging Multi-Dimensional Electrical Resistivity Structure as A Tool in Developing EGS (\$208k)



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Drilling

	FY05 Budget
Drilling and Well Construction	\$3933k
High Temperature Electronics (SNL)	\$900k
Wellbore Integrity and Lost Circulation (SNL)	\$300k
Hard Rock Drill Bits (SNL)	\$620k
Diagnostics While Drilling (SNL)	\$1510k
Advanced Concepts (SNL)	\$343k
Acid Resistant Cements (BNL)	\$160k
Technical and Management Support (SNL)	\$100k



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Systems Development

	FY05 Budget
Energy Conversion	\$1967k
Materials (BNL/NREL)	\$380
Heat Transfer (NREL/INEL)	\$500
Components and Instrumentation (INEL)	\$340
Brine Chemistry (LLNL)	\$100
Systems Analysis (NREL/INEL)	\$295
Technical and Management Support (NREL)	\$352



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Verification

GRED II Projects – FY04

	FY04 Budget
U.S. Geothermal Inc., Raft River, Idaho	\$715K
Noramex Corporation, Blue Mountain, Nevada	\$735K
Lake City Geothermal Inc., Lake City, California	\$1,153K
AmeriCulture Inc., Animas Valley, New Mexico	\$555K
Layman Energy Associates, Truckhaven, California	\$1,020
Northern Arizona University, San Francisco Volcanic Field, Arizona	\$115K